PHENOLOGICAL MONITORING OF ALLERGENIC GRASSES IN RECREATIONAL ZONES: RISKS OF AN EARLY POLLEN SEASON IN THE CONTEXT OF REGIONAL FLOWERING VARIABILITY

Andrea Srubková
Czech Hydrometeorological department, branch Brno, Kroftova 43, 616 67 Brno, Czechia

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Abstract
Recreational zones in climatically distinct regions require a specific approach to maintenance management with regard to visitor health. This study analyzes flowering dynamics and the associated pollen production of two key allergenic species: meadow foxtail (*Alopecurus pratensis*) and orchard grass (*Dactylis glomerata*). The monitoring is based on data from three phenological stations: Lednice (South Moravia), Běleč nad Orlicí (East Bohemia), and Mladecko (Silesia). The aim of the research is to quantify temporal differences in the onset and duration of flowering and to determine the periods of highest risk for the pollen season. For meadow foxtail, the results confirm significant variability in the onset of pollen production; however, an increasingly earlier onset of flowering is observed across all sites. A notable difference lies in the flowering duration: in warmer regions, meadow foxtail flowers for an average of 22 days, whereas in cooler areas, this period extends up to 46 days. Orchard grass also exhibits significant variability and an earlier onset of flowering, but maintains an average flowering duration of approximately 23 days across all locations. This study highlights preventive measures and serves as a basis for improving the quality of life and the safe movement of allergy sufferers within recreational zones.

Key words: Flowering phenophase, allergies, *poaceae* family, recreation

Introduction
Phenology, the study of periodically recurring biological events in relation to environmental conditions, currently represents one of the most sensitive bioindicators of ongoing global climate change. In Central European conditions, this trend is manifested by a shift in the onset of phenophases and an extension of the growing season. Grasses of the Poaceae family belong to the taxonomic group with the highest socio-economic and medical impact on human society, as they are the dominant source of airborne allergens during the summer period (Hájková, 2012; Ziska et al., 2000). The long-term rise in average temperatures, combined with increasing concentrations of atmospheric carbon dioxide, not only results in the accelerated development of grasses and earlier pollen release but also demonstrably increases total pollen production. The phenomenon of an early pollen season onset is not spatially homogeneous, as it is characterized by regional variability and the specific microclimate of urbanized areas (Andersson & Lidholm, 2003; Ziska et al., 2000).

In the context of recreational zones, such as urban parks, playgrounds, landscape heritage sites, and sports facilities, the monitoring of allergenic grasses is of great significance. These areas concentrate a high number of individuals suffering from pollinosis, even during periods of peak pollen production. The issue is further compounded by the existence of cross-reactivity between grasses and woody species such as ash, pine, juniper, and cypress (Weber, 2007; García-Mozo, 2017). Despite these risks, detailed monitoring of grasses at the scale of recreational areas is often neglected; yet, understanding the local flowering dynamics can serve as a key tool for effective adaptive green space management or for designing measures aimed at minimizing health risks. This study analyzes the flowering dynamics of meadow foxtail (Alopecurus pratensis) and orchard grass (Dactylis glomerata) at the Lednice, Běleč nad Orlicí, and Mladecko sites. The aim of the research is to quantify temporal differences in the onset and duration of flowering and to determine the periods of highest risk for pollen production across these diverse territories.

Materials and methods
Selected phenological phases are observed and the data subsequently processed in accordance with the methodology developed by the Czech Hydrometeorological Institute (CHMI), (Návod pro činnost fenologických stanic. Metodický předpis č. 1 - Lesní rostliny; Praha, 2009). For this study, the phenological stations of Lednice, Mladecko, and Běleč nad Orlicí were selected. The data have been evaluated starting from 1991 (Lednice, Běleč nad Orlicí) and 1999 (Mladecko).

Results
The duration of the flowering period for each given site and species is evaluated over the maximum

possible or current monitoring period. Individual phenophases are designated by abbreviations according to the aforementioned CHMI methodology for forest woody species: PK10 (onset of flowering 10%), PK50 (onset of flowering 50%), PK100 (onset of flowering 100%), and KK (end of flowering).
In the Lednice na Moravě locality, monitoring was conducted from 1991 to 2022. As shown in Figure 1, a pronounced variability in the onset of flowering for meadow foxtail has been observed over the last ten years. The difference between the earliest year (2014) and the latest onset (2012) is nearly 31 days. On average, meadow foxtail began flowering around the 121st day of the year (around the beginning of May), with a flowering duration of approximately 21 days, ending in late May. The shortest flowering period was recorded in the final year of observation, lasting 10 days, while the longest was in 2011, spanning 39 days.

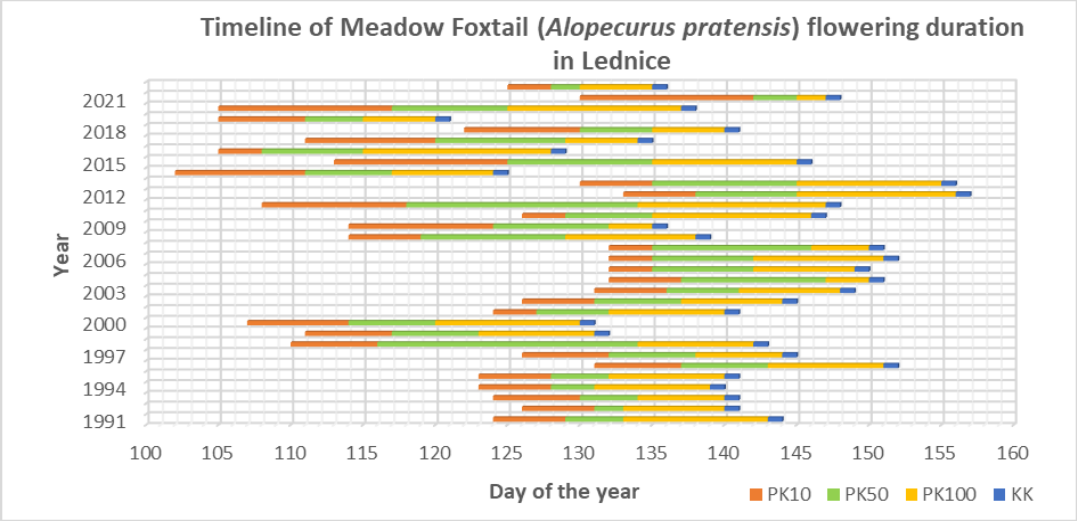

Figure 1: Timeline of meadow foxtail flowering duration in Lednice

Phenological monitoring of orchard grass in Lednice (Figure 2) shows an even greater variance in the onset of flowering, ranging from approximately the 108th day in 2016 to the 155th day in 1991. The results also indicate instability in both the onset and duration of flowering over the last decade; however, it can be clearly stated that the onset occurs significantly earlier compared to the 1990s. In this locality, orchard grass began flowering on average around the 135th day of the year (the second half of May), with an average flowering duration of 23 days. The difference between the shortest flowering period (2021) and the longest (2011) is a remarkable 64 days.

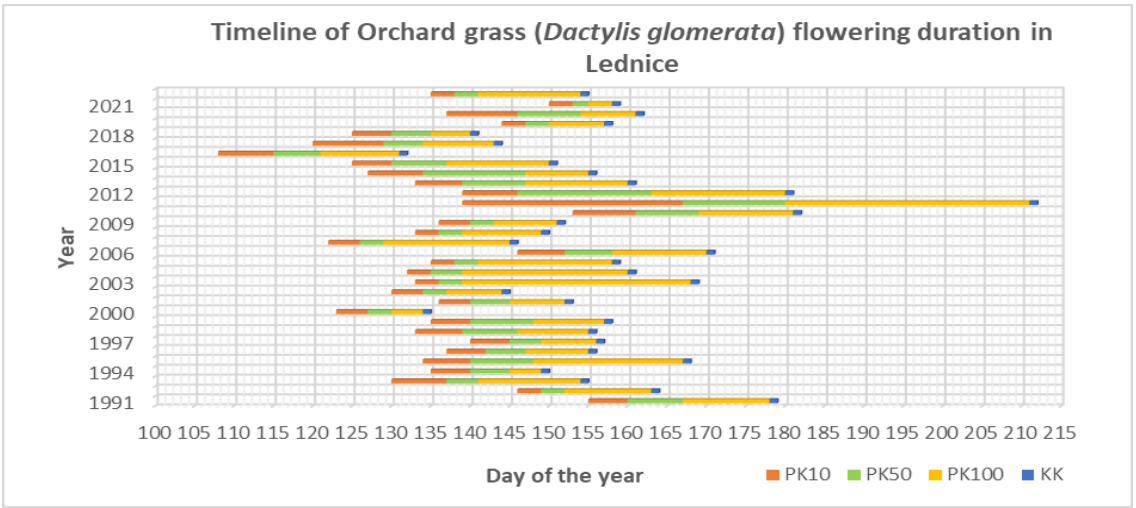

Figure 2: Timeline of orchard grassl flowering duration in Lednice

Another area of interest is Běleč nad Orlicí, located in the Hradec Králové Region. At this phenological station, measurements have been ongoing since 1991. For meadow foxtail, interannual fluctuations in the onset of flowering are evident (Figure 3), with a difference of up to 30 days between the earliest and latest onset. Data from the last two years show a very early onset, confirming the risk of an early overlap between grass pollen loads and fading woody plant allergens. This significantly increases the exposure risk in the region's recreational areas. On average, meadow foxtail begins flowering on the 133rd day of the year (the first half of May), with a flowering duration of approximately 22 days, ending in early June. The difference between the shortest flowering period (1993) and the longest (2013) is 23 days. Analysis of the phenological data for orchard grass in Běleč nad Orlicí (Figure 4) reveals a trend toward an earlier onset of flowering, with the last two years exhibiting some of the earliest values in the entire time series. The pronounced interannual variability, particularly evident when compared to extremely late years such as 1991 or 1992, confirms the high sensitivity of this species to local climatic factors. In this locality, orchard grass began flowering on average around the 143st day of the year (the second half of May) and flowered for an average of 22 days.

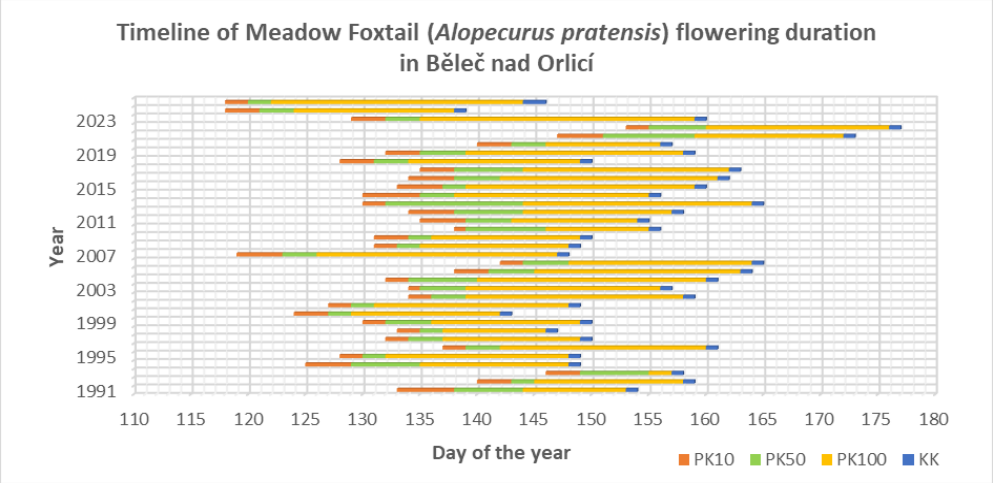

Figure 3: Timeline of meadow foxtail flowering duration in Běleč nad Orlicí

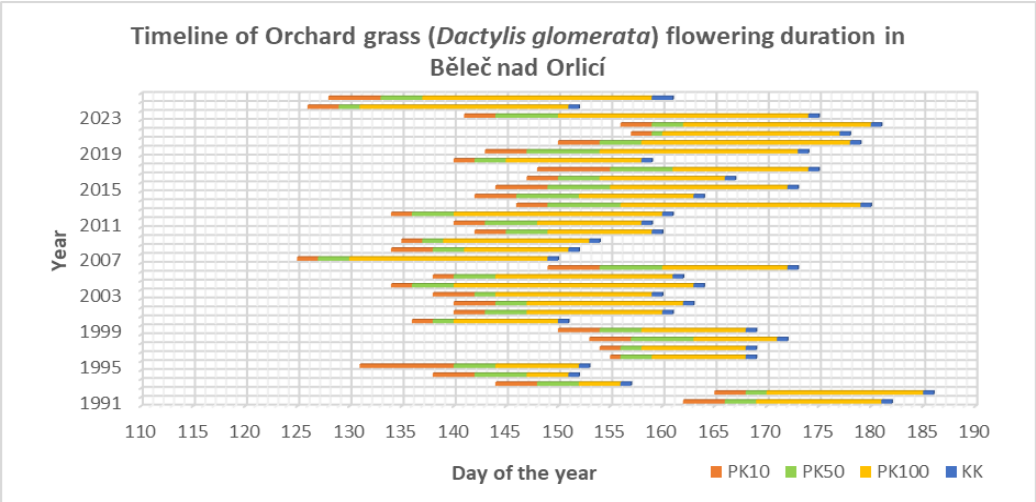

Figure 4: Timeline of orchard grassl flowering duration in Běleč nad Orlicí

The final set of analyzed data comes from the Mladecko phenological station, located in the Opava District within the Moravian-Silesian Region. Monitoring began in 1999 and continues to the present. In the last two years (2024–2025), meadow foxtail (Figure 5) has exhibited an earlier onset of flowering, starting around the 110th day of the year, which represents a significant shift compared to the average of previous decades. A distinctive feature of this locality is a considerable extension of the full flowering phase. Similar to the two previous sites, meadow foxtail generally begins to flower in early May; however, there is a substantial difference in the duration of flowering, which averages 46 days. The difference between the longest flowering period (2024) and the shortest (2000) is 35 days.

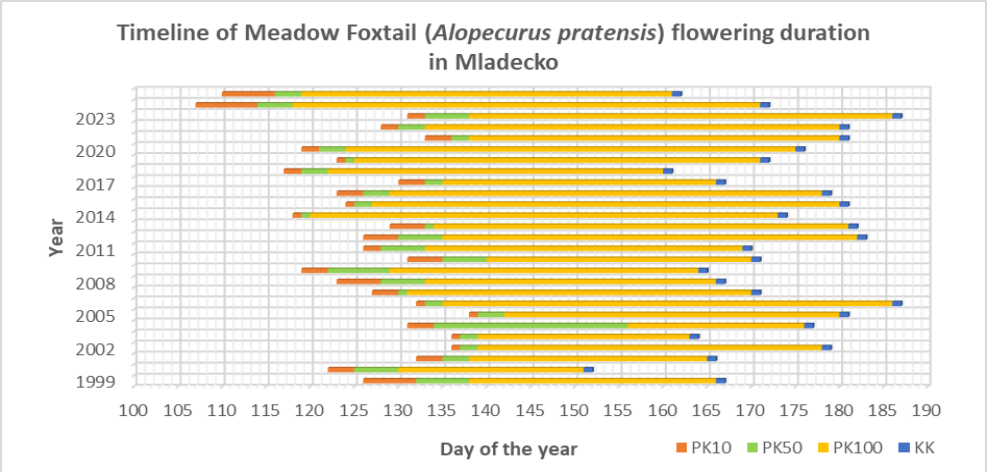

Figure 5: Timeline of meadow foxtail flowering duration in Mladecko

The phenophases of orchard grass in Mladecko (Figure 6) also show a shift toward earlier flowering in the last two years compared to previous decades; however, unlike meadow foxtail, interannual variability is present. On average, it begins to flower around the 148th day of the year, which is later than in Lednice or Běleč nad Orlicí, but the flowering duration is comparable, lasting approximately 24 days. The difference between the longest flowering period (2013) and the shortest (2000) is 28 days.

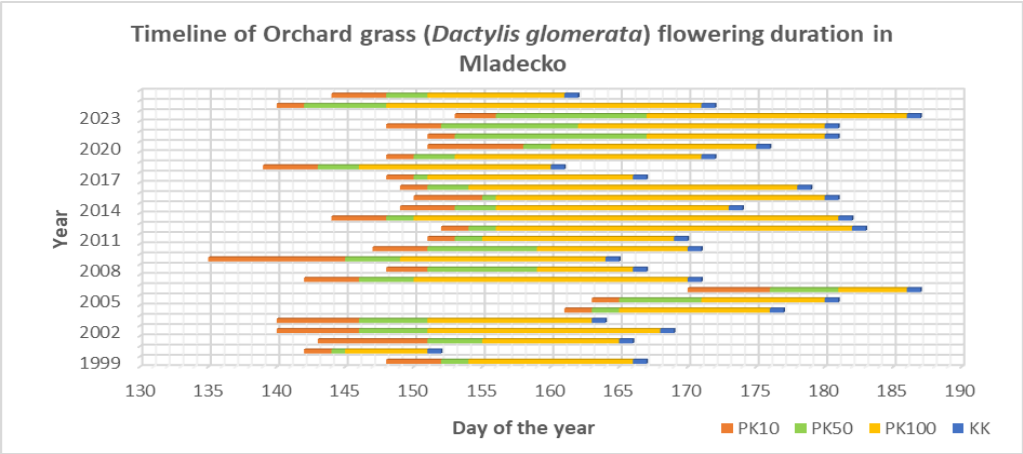

Figure 6: Timeline of orchard grassl flowering duration in Mladecko

Discussion

A comparison of the results of this study with the work of Kožnarová et al. (2011) confirms the long-term trend of extending flowering durations in key allergenic grasses, such as orchard grass and meadow foxtail. While Kožnarová identified the years 2000, 2007, and 2009 (within the 1991–2010 evaluation period) as periods with significantly accelerated phenophase onset, our data from the last fifteen years particularly the extreme years of 2024 and 2025 show that the acceleration process is further intensifying and that previous deviations are becoming the new standard. This shift of the "early pollen season" deeper into April increases the risk of overlap with woody plant allergens, confirming the growing vulnerability of the monitored sites to the impacts of climate change.

Conclusion

Phenological analysis confirmed that the earlier onset of grass flowering is becoming a new trend, with data since 2020 showing a shift in the pollen season of more than three weeks compared to historical averages. To maintain the accessibility and safety of recreational zones, it is critical to move away from fixed calendar-based maintenance schedules and implement dynamic mowing management driven by current temperature trends. Only the timely elimination of flowering culms can effectively reduce the allergenic load for visitors or, at the very least, mitigate the cross-reactivity between grasses and woody species.

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Souhrn
Studie se zabývá analýzou fenologických řad alergenních travin psárky luční a srhy říznačky v lokalitách Lednice, Běleč nad Orlicí a Mladecko. Analýza potvrdila jasný trend urychlení nástupu kvetení a prodlužování délky kvetení. Zatímco v 90. letech byl nástup kvetení (PK10) koncentrován do měsíce května, v posledním pětiletí (2021-2025) dochází k časnějším nástupům již do poloviny dubna. Prodlužování fáze plného kvetení (PK100) indikuje vysokou odlišnost reakce trav na oteplování než se tomu dělo před třiceti lety. Studii lze zařadit do tří kategorií, a to vědecké, zdravotní a praktické, protože oteplování není jen teoretický pojem, ale měřitelný fakt. Pylová sezóna se neustále posouvá dopředu a smyslem práce je poukázat díky zpracovaným datům na možná rizika a přizpůsobit management údržby seče v rekreačních zónách.

Contact:
Ing. Andrea Srubková
E-mail: andrea.srubkova@chmi.cz